Hybrid Hydrogels as 4D Biomimetic Systems

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The rapid development of nanomaterials in the last decades has opened up a new dimension in research. Their extraordinary mechanical, electrical, thermal, and optical properties hold the promise to revolutionize fields like electronics, sensing, energy, and composites, among others. Contemporarily to this nano fashion, 3D structures have gained growing interest in biomedical research. Simplistic 2D cell cultures, used since the early 1900s to represent tissue cells *in* vitro, have given way to 3D models aimed at producing more physiologically relevant tissues.

In this talk, we will discuss how nanomaterials contribute to the design of soft 3D bio-mimicking systems. In our laboratories, the synthesis of different hydrophilic polymeric networks, by in situ radical polymerization in the presence of 2D materials or metal nanoparticles, gives rise to three-dimensional nanocomposite soft scaffolds. The role of the nanomaterial within the polymer network is primarily intended for the reinforcing (i.e., increasing the stiffness and toughness). However, we have shown that it can also enhance features such as biocompatibility, sensing, or self-healing ability, giving rise to truly hybrid composites.

In addition, the possibility of preparation following 3D printing methodologies, using concentric layers of different materials with varying mechanical properties, allows the development of novel cell culture systems that more closely emulate natural processes. The systems are intended to be much more than traditional static scaffolds, as they respond to external stimuli, such as magnetic or electrical activation, thus converting them into 4D scaffolds.